



## 3-5: Observing Solar Energy

## Lesson Plan

### Purpose:

Students analyze map visualizations representing the amount of Sun's energy received on the Earth as indicated by the the amount that is reflected back to space, known as "albedo". Engaging their prior knowledge of seasons and climate, students make inferences about the relative months that these data represent. This lesson includes a regional dataset of the Chicago, Illinois area where students observe the map visualizations and compare them to a line graph of Earth's absorption of the Sun's radiation in 2015 to understand how data is represented in a variety of ways.

<p><b>Grade Level:</b> 3-5  <b>Time:</b> 2-45 minute class periods  <b>MND Lesson # 84</b></p>	<p><b>Lesson Objectives:</b></p> <ul style="list-style-type: none"> <li>• The students will make observations of World Albedo Maps in order to make inferences and explanations about the phenomenon.</li> <li>• Students will analyze and discuss visualizations of global and regional solar radiation data collected in 2015.</li> <li>• Students interpret the visualization models representing the same data sets to describe seasonal changes.</li> </ul>	<p><b>Sphere(s):</b></p> <ul style="list-style-type: none"> <li>• Atmosphere</li> <li>• Hydrosphere</li> </ul>
<p><b>Phenomena NASA Connection:</b></p> <p>When sunlight reaches the Earth's surface, some of it is absorbed and some is reflected. The relative amount (ratio) of light that a surface reflects compared to the total sunlight that falls on it is called <b>albedo</b>. Surfaces that reflect a lot of the light falling on them are bright, and they have a high albedo. Surfaces that don't reflect much light are dark, and they have a low albedo.</p> <p>NASA scientists use data from multiple satellites to analyze albedo and its effect on weather and climate. In this My NASA Data Lesson, Observing Solar Energy, students observe different visualizations to identify patterns of average albedo values as they change from one month to another in 2015. GLOBE and MY NASA DATA enable educators and students to connect with NASA scientists and access the satellite data to answer their own questions related to atmospheric interactions.</p>		
<p><b>Essential Questions:</b></p> <ol style="list-style-type: none"> <li>1. How is the Earth affected by the change in Sun's energy?</li> <li>2. What factors affect the amount of Sun's energy absorbed? reflected?</li> </ol>		
<p><b>NGSS Performance Expectation(s):</b></p> <ul style="list-style-type: none"> <li>• <b>3-ESS2-1</b> Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.</li> <li>• <b>3-ESS2-2</b> Obtain and combine information to describe climates in different regions of the world.</li> <li>• <b>4-PS3-2</b> Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.</li> </ul>		



- **4-PS3-1** Use evidence (e.g., measurements, observations, patterns) to construct an explanation.
- **5-ESS2-1** Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere and/or atmosphere interact.

#### Science & Engineering Practices:

##### Analyzing and Interpreting Data:

Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationship.

**Developing and Using Models:** Develop a model using an example to describe a scientific principle.

##### Obtaining, Evaluating, and

**Communicating Information:** Obtain and combine information from books and other reliable media to explain phenomena.

#### Disciplinary Core Ideas:

##### ESS2.D Weather and Climate:

Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.

#### Crosscutting Concepts:

**Patterns:** Patterns of change can be used to make predictions.

**Systems and System Models:** A system can be described in terms of its components and their interactions.

**Energy and Matter:** Energy can be transferred in various ways and between objects.

**NCTM Math Standards:** n/a

#### Cross-Curricular Connections:

##### National Geography Standards:

-How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.

#### Career Connections:

- o **Atmospheric and Space Scientists** – Investigate weather and climate related phenomena to prepare weather and climate related phenomena to prepare weather reports and forecasts for the public
- o **Computer and Information Scientists** – Conduct research in the field of computer and information science
- o **Cartographers and Photogrammetrists** – Collect, analyze, and interpret geographic data in creation of maps
- o **Applications Software Developers** – Develop and modify computer applications software that are used to communicate with satellites and people using satellite data
  - Computer Programmers
  - Systems Engineers
  - Software Engineers

#### Multimedia Resources:

- YouTube: "What is Albedo?" (see [link](#)), <https://youtu.be/uWZEvZ118DM?t=6s>
- NASA Missions (see links)
  - o [CERES](http://ceres.larc.nasa.gov/) (<http://ceres.larc.nasa.gov/>)
  - o [Tropical Rainfall Measuring](http://ceres.larc.nasa.gov/) (<http://ceres.larc.nasa.gov/>)
  - o [Mission](http://trmm.gsfc.nasa.gov/) (<http://trmm.gsfc.nasa.gov/>)
  - o [Terra](http://terra.nasa.gov/) (<http://terra.nasa.gov/>)
  - o [Aqua](http://aqua.nasa.gov/) (<http://aqua.nasa.gov/>)
  - o [Suomi-NPP](http://jointmission.gsfc.nasa.gov/suomi.html/) (<http://jointmission.gsfc.nasa.gov/suomi.html/>)
  - o [JPSS-1 satellite](http://jointmission.gsfc.nasa.gov/jpss.html/) ([http://jointmission.gsfc.nasa.gov/jpss.html](http://jointmission.gsfc.nasa.gov/jpss.html/))

#### Materials/Resources Needed:

#### Key Vocabulary:



<p><u>Per Student:</u></p> <ul style="list-style-type: none"><li>• Datasheet</li></ul> <p><u>Per Group:</u></p> <p><u>Part 1:</u></p> <ul style="list-style-type: none"><li>• <u>Set 1:</u> 2015 World Map of Albedo (Jan, Jul, Oct)</li></ul> <p><u>Part 2:</u></p> <ul style="list-style-type: none"><li>• <u>Set 2:</u> 2015 Map of Albedo in the Greater Chicago, Illinois Area (Jul, Oct., Dec)</li><li>• Graph 2015 Albedo Values for Chicago, Illinois Area</li></ul> <p><u>Per Class:</u></p> <ul style="list-style-type: none"><li>• OPTIONAL: Globe/s to help facilitate understanding of the role of the Earth's tilt</li></ul>	<ul style="list-style-type: none"><li>• Albedo</li><li>• Radiation</li><li>• Observations</li><li>• Energy</li><li>• Temperature</li></ul>
<p><b>Teacher Background:</b></p> <p>The energy coming from the Sun to the Earth's surface is called solar energy. Every day, the Sun radiates an enormous amount of energy. Most of it is in the form of radiation from the "visible" wavelengths, i.e., those responsible for the light detected by our eyes. Visible radiation and radiation with shorter wavelengths, such as ultraviolet radiation are labeled "shortwave." The temperature of the Sun's radiating surface, or photosphere, is more than 5500°C (9900°F).</p> <p>Not all of the Sun's energy comes to Earth. The Sun's energy is emitted in all directions, with only a small fraction being in the direction of the Earth. The amount of solar energy a place on Earth receives depends on several conditions. Mostly, it depends on latitude (as it relates to the season of the year, the angle of the Sun, and the amount of daylight hours), but it also depends on the clearness or cloudiness of the sky.</p> <p>Energy goes back to space from the Earth system in two ways: reflection and emission. Part of the solar energy that comes to Earth is reflected back out to space in the same, short wavelengths in which it came to Earth. The fraction of solar energy that is reflected back to space is called the albedo.</p> <p>Different parts of the Earth have different albedos. For example, ocean surfaces and rain forests have low albedos, which means that they reflect only a small portion of the Sun's energy. Deserts, ice, and clouds, however, have high albedos; they reflect a large portion of the Sun's energy. Over the whole surface of the Earth, about 30 percent of incoming solar energy is reflected back to space. The average albedo for Earth is about 0.3. The albedo values can also be more localized, which is controlled by the amount of Sun's light reflected from a particular place and time; it also depends on the local surface that may change seasonally such as gardens, forests, etc. It also depends on events that change more quickly such as ones that affect clouds and snow patterns.</p>	
<p><b>Prerequisite Student Knowledge:</b></p> <ul style="list-style-type: none"><li>• Knowledge that energy from the Sun is responsible for heating land, air, and water of the Earth</li><li>• Basic knowledge of names and locations of continents</li><li>• General knowledge of difference between absorption and reflection</li></ul>	
<p><b>Possible Misconceptions:</b></p> <ul style="list-style-type: none"><li>• The thermal energy of an object is not related to the material the object is made of (Herrmann-Abell &amp; DeBoer, 2009).</li><li>• Energy is not transferred from one object to another unless those objects are in direct contact with each other.</li></ul>	



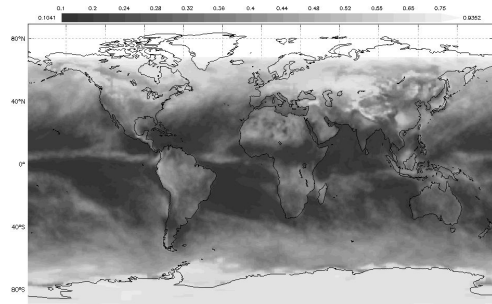
-Taken from AAAS Science Links

## Procedure:

### Part 1: Global Comparisons of Albedo:

1. Explain that students will be observing maps that show the Sun's energy absorbed by Earth or reflected back to space. Now show the Youtube video [link](#), show until 1:15.

- A. What is albedo? *The relative amount (ratio) of light that a surface reflects compared to the total sunlight that falls on it is called albedo*
- B. What happens when Sun's light reaches the Earth? *When sunlight reaches the Earth's surface, some of it is absorbed and some is reflected.*
- C. What affects this absorption or reflection? *Surfaces that reflect a lot of light are bright, and they are said to have a high albedo. For example, a totally white surface has an albedo of 1.0 whereby all light is reflected. In comparison, surfaces that don't reflect much light are dark, and they are said to have a low albedo. A totally black material has an albedo of 0 where all energy is absorbed.*
- D. What are natural surfaces on Earth that have a high albedo? Low? *Snow has a high albedo, and forests have a low albedo. All surfaces have an albedo value that is measured on a scale from 0 to 1; where 0 is a true black surface without any reflection, and 1 represents a white surface with complete reflection. A dark object absorbs many wavelengths of light energy and converts them into heat, so the object gets warm. In contrast, a white object reflects all wavelengths of light. The light is not converted into heat and the temperature of the white object does not increase noticeably. Thus, dark objects—such as building materials—absorb heat from the Sun.*
- E. What if Earth was completely covered in ice, its albedo would be about 0.8. What would this mean; how would this affect our planet? *The ice would reflect most (80 percent) of the sunlight that hit it; the planet would be very cold because little of the Sun's energy would be absorbed.*
- F. On the other hand, how would the Earth be affected if it was covered by a dark green forest canopy? *The albedo would be much lower (about 0.1) and most of the sunlight would get absorbed; this would increase our temperatures significantly.*
- G. What types of changes in the Earth System affect global albedo? *Changes in ice cover, cloudiness, airborne pollution, or land cover (from forest to farmland, for instance).*
- H. How do scientists measure albedo values? *For seventeen years, scientists have been examining albedo with a series of space-based sensors known as [Clouds and the Earth's Radiant Energy System](#), or CERES. The instruments use scanning radiometers to measure both the shortwave solar energy reflected by the planet (albedo) and the longwave thermal energy emitted by it. The first CERES went into space in 1997 on the [Tropical Rainfall Measuring Mission](#), and three more have gone up on [Terra](#), [Aqua](#), and [Suomi-NPP](#). The last remaining CERES instrument will fly on the [JPSS-1 satellite](#), and a follow-on, the Radiation Budget Instrument (RBI), will fly on JPSS-2.*
- I. Predict the Earth's average albedo. *Scientists estimate Earth's average albedo is about about 0.30.*



### Part 2: Global Albedo Observations and Comparisons

2. Hand out and/or display the Set 1A: World Map of Albedo (January 2015) **without showing or mentioning the month that this image was collected.**

3. Briefly describe that the map is showing a range of values. Take a look at the legend's scale to the at the top of the map; ask students to identify the lowest value of the range and its color: 0.1041, black and the highest value of the range: 0.9352, white. Also have students identify the units: fraction. (Teacher Note: This is a great opportunity to have students convert these amounts to fractions.





*This shows how much of the Sun's energy is reflected back into space - some of the land, water, or air in the Sun's path, is not heated by this energy.*

4. In a Think-Ink-Pair-Share, students brainstorm at least five words, concepts, or drawings that come to mind when thinking about the months of the year. Students will write or draw one word or phrase on each Post-it.

- Students will come to the board and post their ideas.
- As a class, organize students' ideas on the board by ones that are activities (i.e. ice skating, swimming, etc.) vs. ones that are conditions (i.e. flowers grow, rain, snow, etc.). The teacher should try to organize ideas around seasons.
- Ask students to predict the season that they believe this image captures. Have students explain the evidence that they have to support the claim. (Claim - one sentence that answers the question, Evidence - use of enough qualitative (using senses) and quantitative (numerical) to support claim.)



Absorbs light = Warmer, absorbs Sun's energy



Reflects light = Cooler, reflects Sun's energy

5. Draw two boxes on the board - one shaded in black, the other in white. Ask students what effect does the color have on the temperature.

6. Look more closely at the January 2015 World Map of Albedo. Select different values of high, medium, and low values of albedo. Ask students which continents have the highest values of albedo (*Antarctica, North America to about 40° N, Asia to approximately 30° N*).

7. Now, compare the January image to the Set 1B: World Map of Albedo (July 2015) World Map of Albedo **without showing or mentioning the month that this image was collected.**

Select different values of high, medium, and low values of albedo. Ask students which continents have the highest values of albedo (*Antarctica to approximately 50°S, North America to about 60° N, Asia to approximately 60° N*). Ask students to predict the season that they believe this image captures. Have students explain the evidence that they have to support the claim.

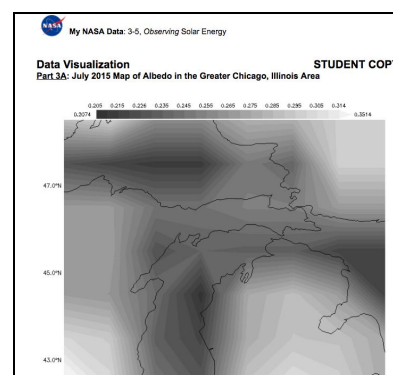
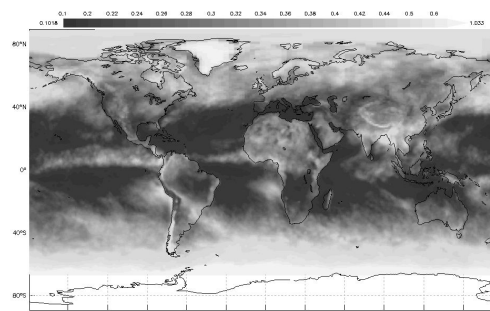
8. Repeat Step 7 with Set 1C: World Map of Albedo (October 2015) World Map of Albedo **without showing or mentioning the month that this image was collected.**

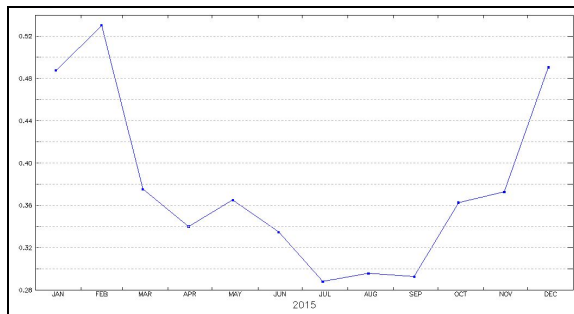
#### Part 3: Chicago, Illinois Comparisons of Albedo:

To bring in a more regional context to this lesson, students compare the images of the Greater Chicago Region (Set 2) and related graph.


1. Brainstorm with the class, what they know about Chicago (i.e., urban environment with many sidewalks, streets, parking lots and tall buildings, and few forests. These structures are usually made up of materials such as cement, asphalt, brick, glass, steel and dark roofs.)

2. Ask students to predict the albedo values of the most common materials, such as asphalt, steel, and brick. These are often very dark colors with lower albedo values—like black, brown and grey. How would these dark materials affect Chicago? *Lead to warmer temperatures.*





Graph 2015 Albedo Values for Chicago, Illinois Area

3. Distribute Set 2A: Map of Albedo in the Greater Chicago, Illinois Area (July 2015 ) **without showing or mentioning the month that this image was collected.** Identify Chicago's location by the  icon. Students analyze the data visualization and describe the different values of high, medium, and low values of albedo and areas. What are the possible effects of these values?
4. Next, students compare these areas with the other images from the set.
5. Disseminate Graph 2015 Albedo Values for Chicago, Illinois Area to students. Review key features of the graph with the students (i.e., title, X and Y axes labels, scale of the axes, units, etc.)
6. Explore the data on the graph with students. Ask for students to identify the month with the highest absorptions of Sun's radiation and lowest albedo (*July*). Lowest absorptions of Sun's radiation and the highest albedo (*February*).
7. Finally, have students put Set 2 in chronological order based on what they've learned about albedo.

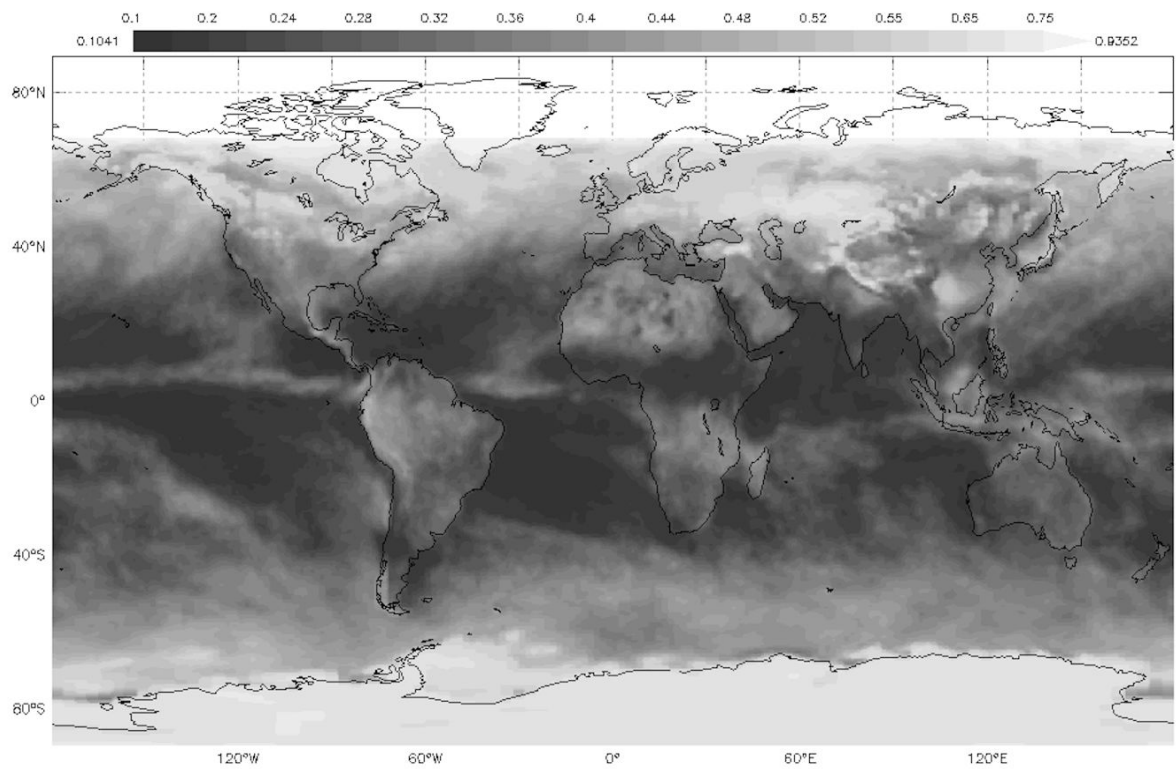




## Data Visualization

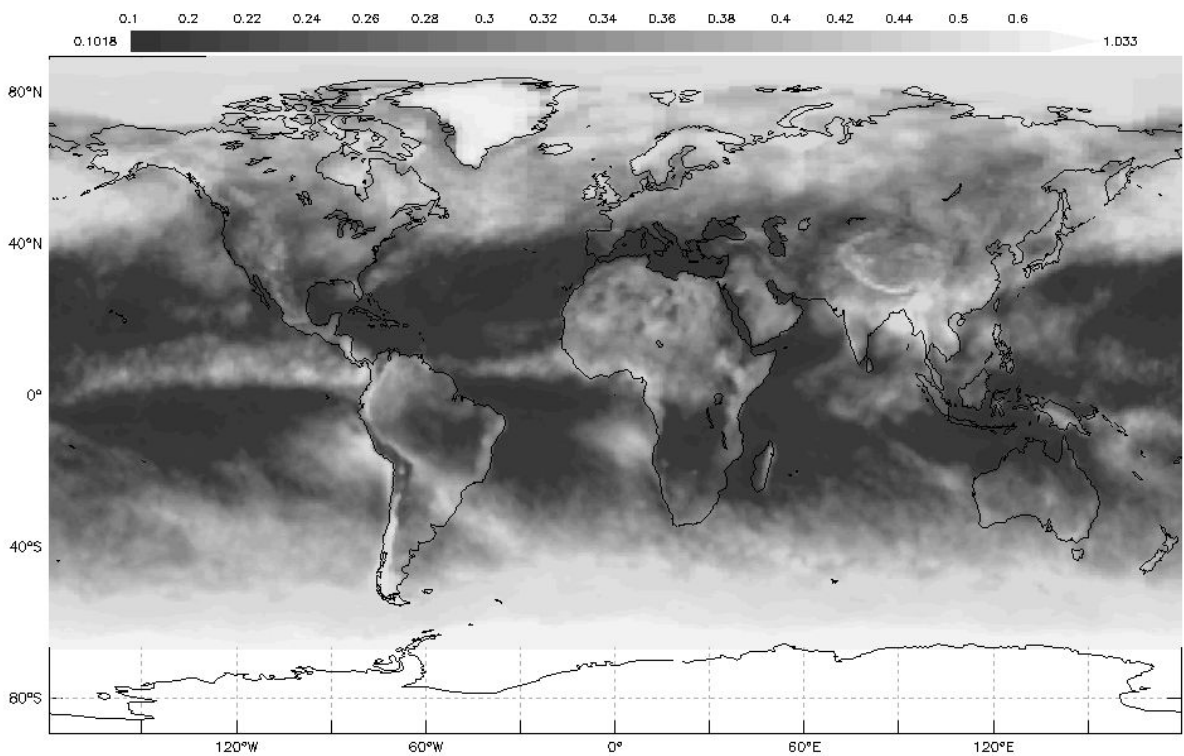
### SET 1A. World Map of Albedo

## STUDENT COPY



## Data Visualization

### SET 1B. World Map of Albedo

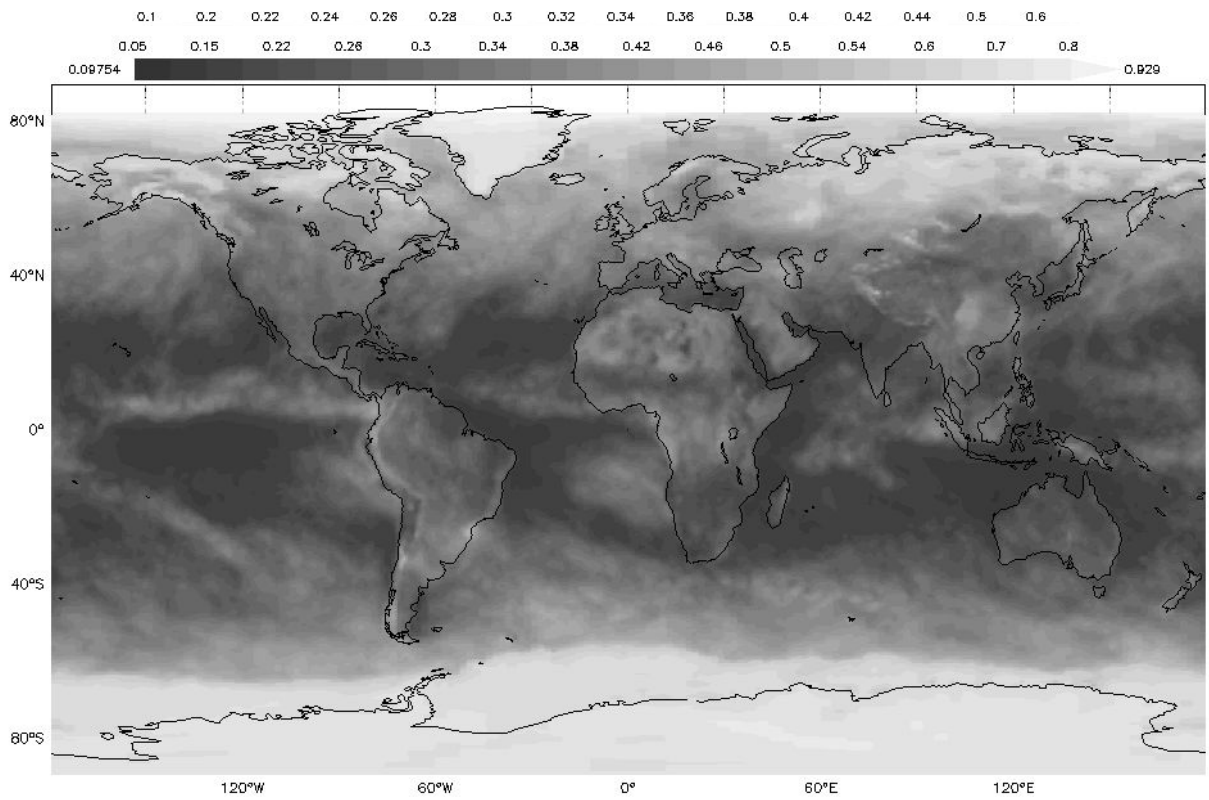




## Data Visualization

### SET 1C. World Map of Albedo

## STUDENT COPY



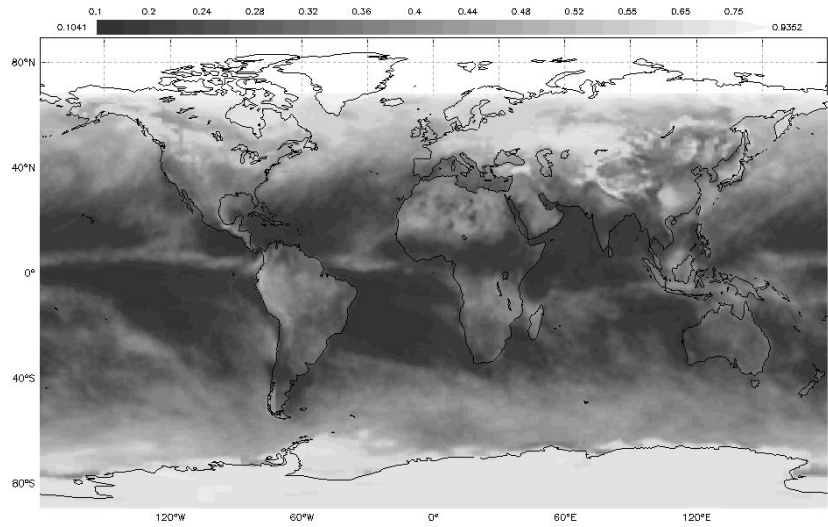




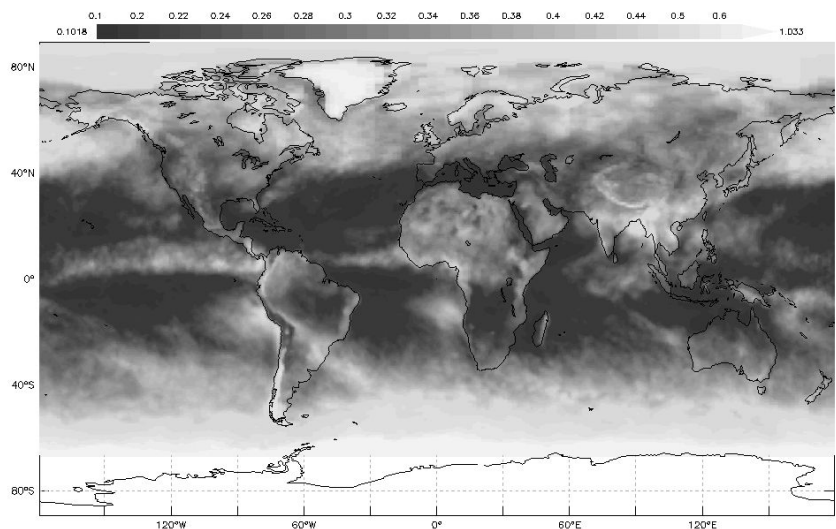
## Data Visualization

## TEACHER KEY

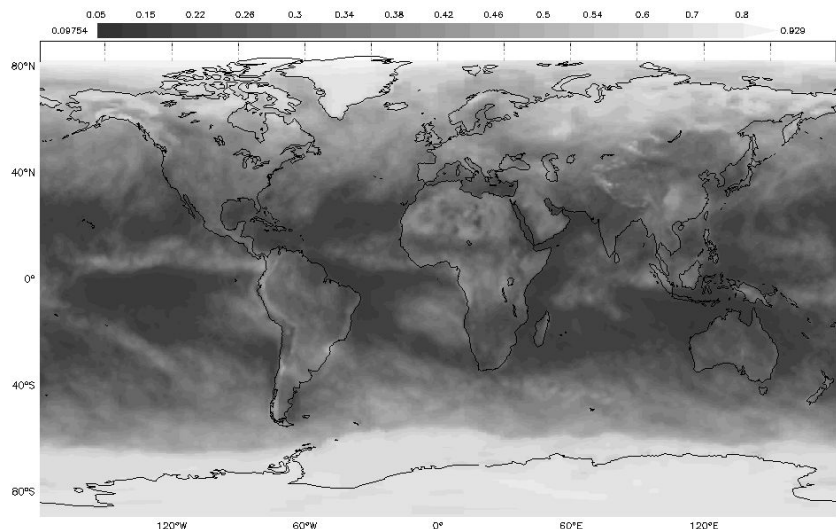
### SET 1A. January 2015 World Map of Albedo



### SET 1B. July 2015 World Map of Albedo



### SET 1C. October 2015 World Map of Albedo

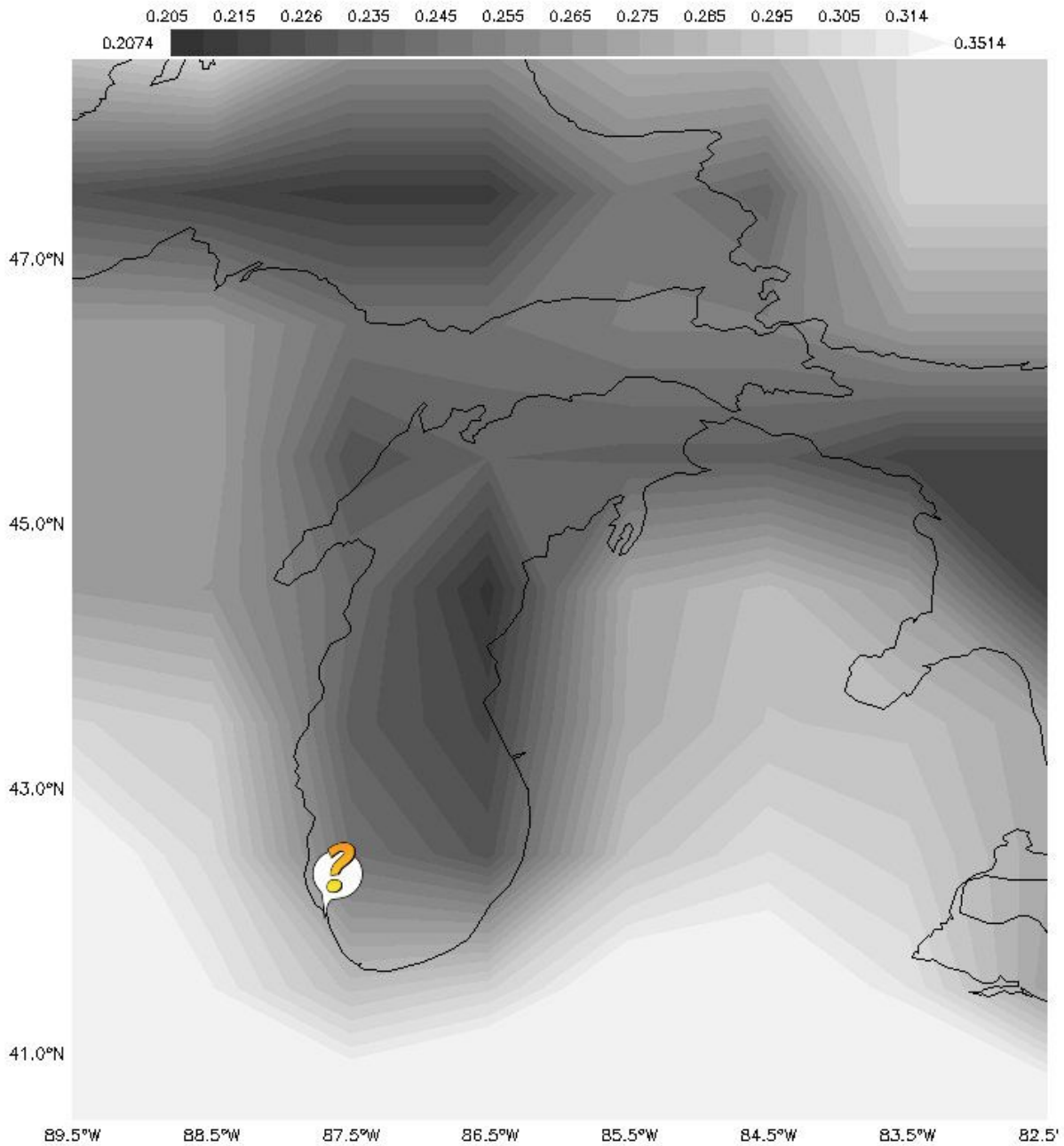




## Data Visualization

## STUDENT COPY

### SET 2A: 2015 Map of Albedo in the Greater Chicago, Illinois Area

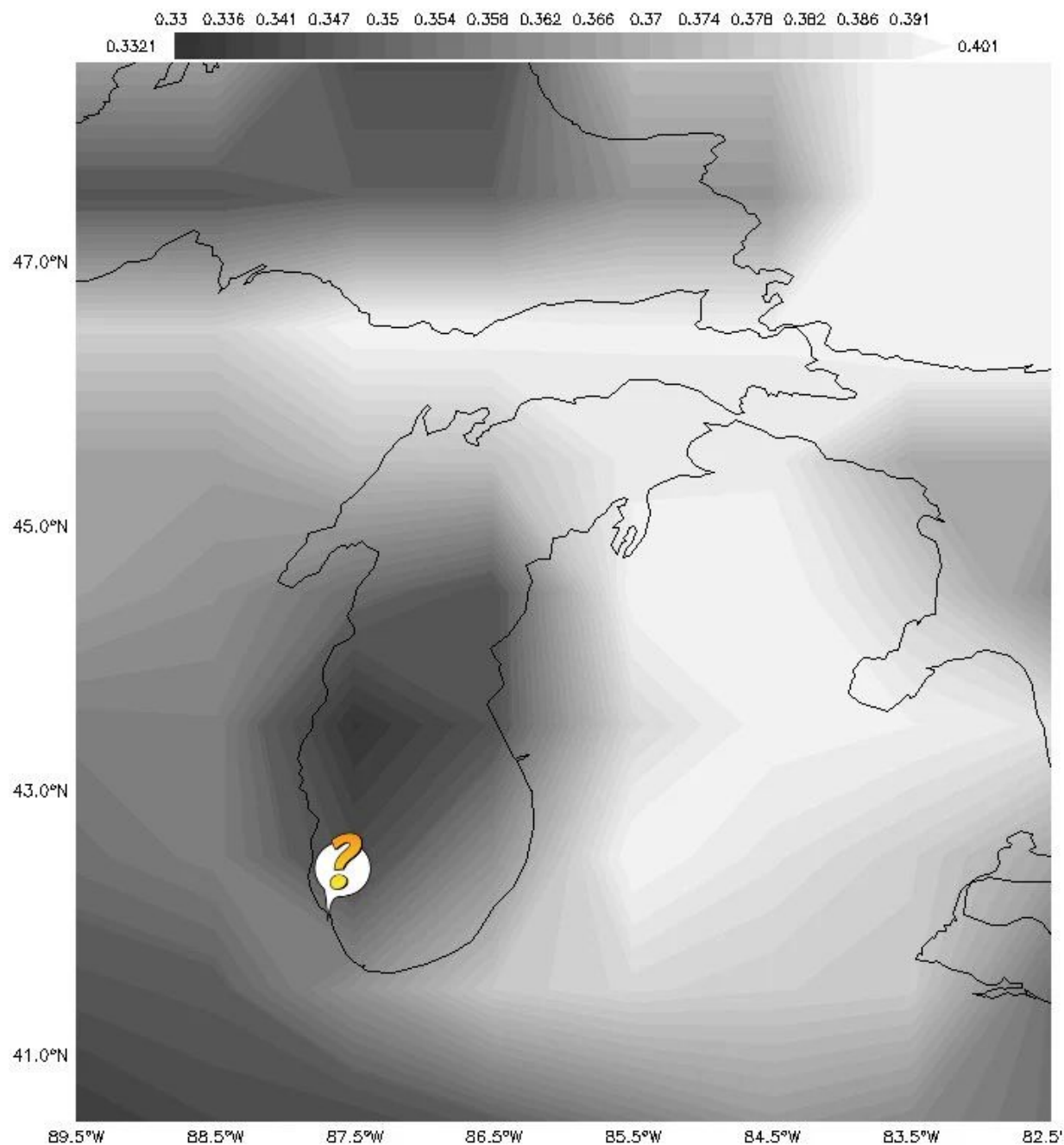




## Data Visualization

## STUDENT COPY

### SET 2B: Map of Albedo in the Greater Chicago, Illinois Area

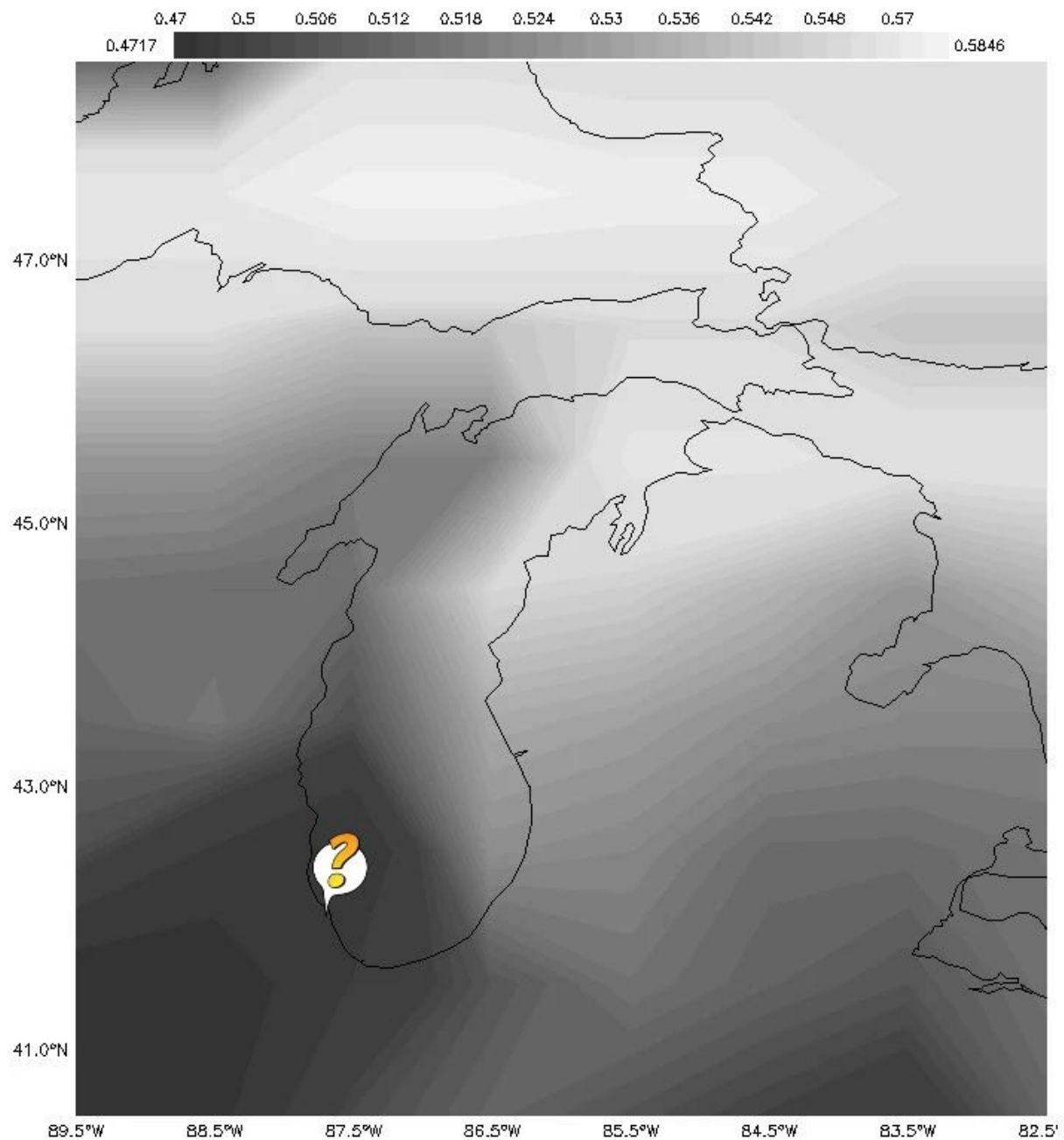




## Data Visualization

## STUDENT COPY

### SET 2C: Map of Albedo in the Greater Chicago, Illinois Area

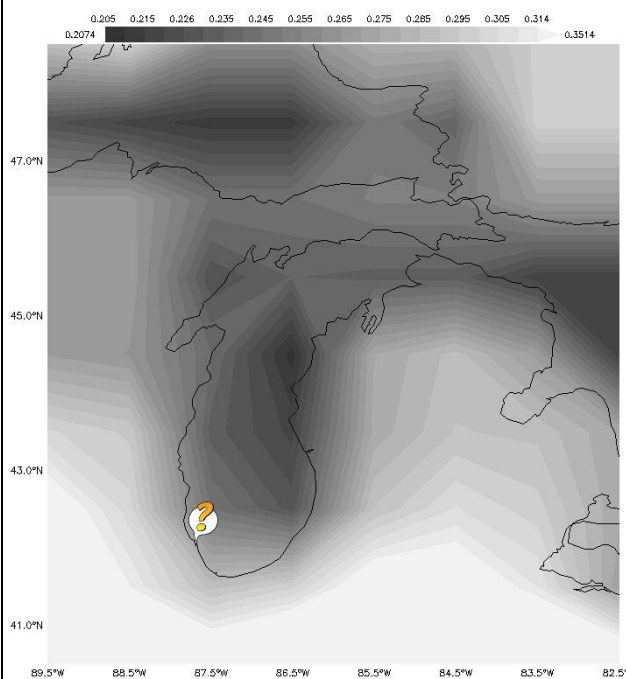




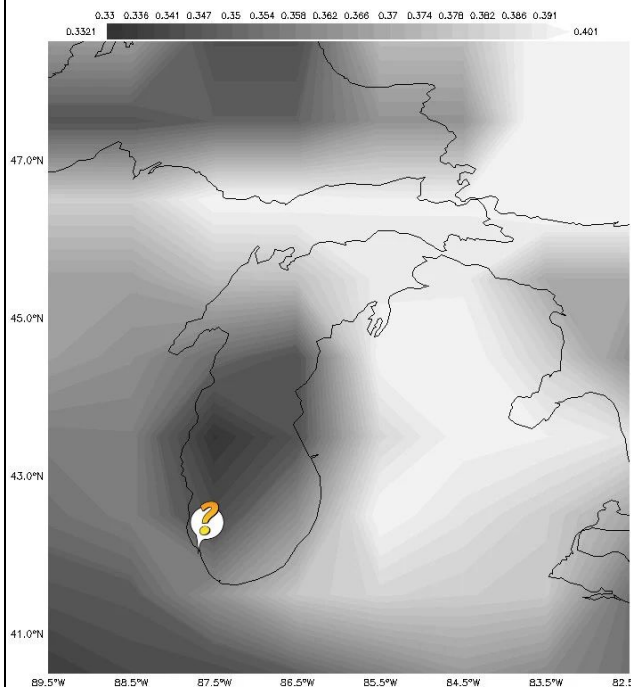
## Data Visualization

## TEACHER KEY

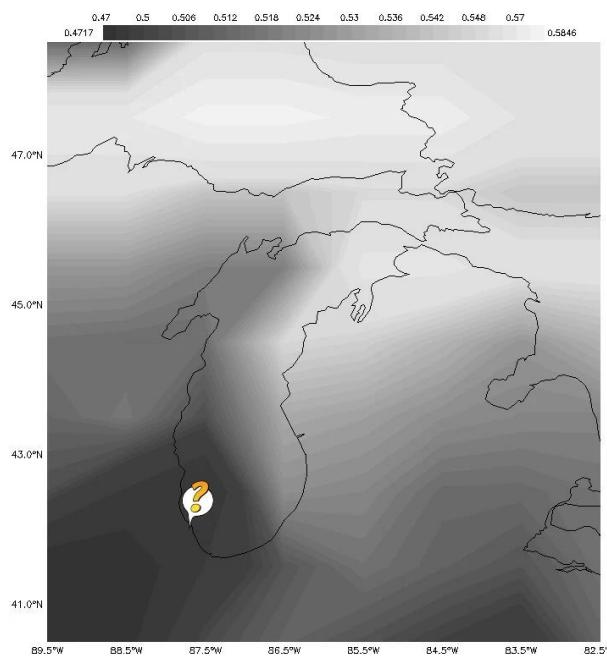
**SET 2A: July 2015 Map of Albedo in the Greater Chicago, Illinois Area**



**SET 2B: October 2015 Map of Albedo in the Greater Chicago, Illinois Area**



**SET 2C: December 2015 Map of Albedo in the Greater Chicago, Illinois Area**







## STUDENT COPY

### Data Visualization 2D: Graph 2015 Albedo Values for Chicago, Illinois Area

DATA SET: Top of Atmosphere (TOA) All Sky  
VARIABLE: Monthly TOA All-sky Albedo (CERES EBAF) (fraction)  
LONGITUDE : 87.5W (-87.5)  
LATITUDE : 41.5N  
OPeNDAP URL:  
[https://mydasdata.larc.nasa.gov/thredds/dodsC/las/atmos\\_rad\\_toa\\_as/data\\_usr\\_local\\_fer\\_data\\_CERES\\_EBAFAlbedo.nc\\_Count\\_adv\\_init\\_albedo.jnl](https://mydasdata.larc.nasa.gov/thredds/dodsC/las/atmos_rad_toa_as/data_usr_local_fer_data_CERES_EBAFAlbedo.nc_Count_adv_init_albedo.jnl)  
LAS 8.6/Ferret 6.95 NOAA/PMEL

